PRE-ASSEMBLED STRUCTURAL FLOOR PANELS

A system of pre-assembled structural floor panels developed by the University of Illinois Small Homes Council under a research grant given by the Lumber Dealers Research Council.

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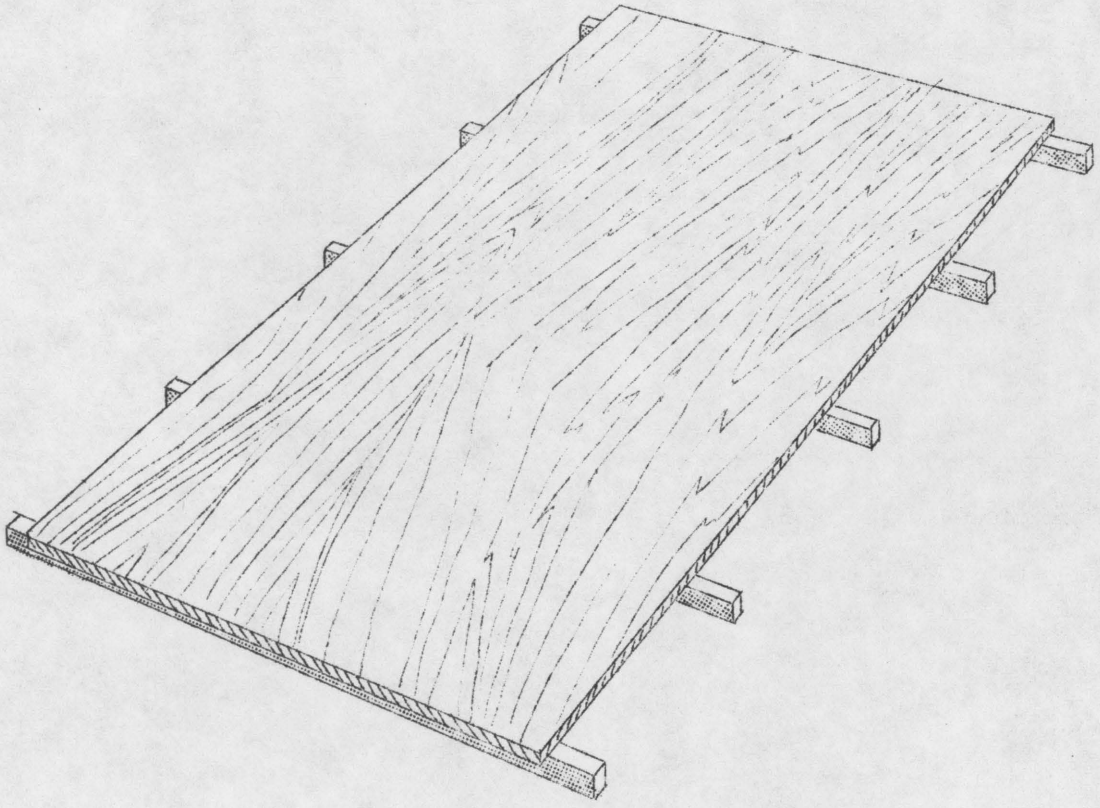

PRE-ASSEMBLED STRUCTURAL FLOOR PANELS

Floors as well as exterior walls and partitions can be built as panels. By panellizing floors, builders can realize those cost savings which are possible by using pre-assembled parts instead of individual pieces of lumber.

The University of Illinois Small Homes Council* has designed a floor panel which can be assembled in the same jig which is used for the pre-assembled wall and partition panels previously developed by the Small Homes Council. The floor panels are designed on the 4-foot module, which is a multiple of the universally accepted 4-inch module.

The floor panel meets primary requirements for efficient panellization:

1. It uses standard sizes and grades of yard lumber.
2. It can be manufactured by comparatively unskilled labor in the lumber dealer's shop or shed, or at site.
3. It is designed so that only a minimum number of standard sizes are necessary.
4. It is light enough to be carried and set into place by two men.
5. It meets criteria of engineering design analysis and performs well under load tests. No new structural systems are involved; therefore, the panel should be readily accepted by building inspectors and insuring agencies (Federal Housing Administration and Veterans Administration).

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* The studies and tests were carried out under the direction of Professor James T. Lendrum, A.I.A., director of the Small Homes Council, and were made by Professor Frank M. Lescher, A.I.A., assisted by Mrs. Sydney B. Bianchini.

BASIC PANEL

The basic panel is 4'-0" x 8'-0" and is made of plywood supported by five 2" x 4" cross members. Variations in length and width of the panels are possible. If the panel is to be covered with asphalt tile, cork, rubber or vinyl flooring, 5/8" plywood should be used. For other flooring materials, ½" plywood is sufficient.

Two major structural designs are possible--one for 4-foot spans and the other for longer spans. These are described below.

Panel Using Splines (4-Foot Span)

In this design, five 2" x 4" cross members which support the plywood serve as joists and rest directly on metal or wood girders which are spaced 4 feet on center. (Figure 1.)

The 2" x 4" cross members are designed so that the panels interlock. The 2" x 4"'s project beyond the plywood and by-pass each other when assembled. The ends of these members are notched, permitting the use of 2" x 4" splines running lengthwise of the panels. Besides connecting the panels, these splines serve also as supporting nailers for the edges of the plywood. (Figure 2.) A cross-section of the panel is shown in Figure 3. Weight of this panel is 90 pounds.

In laying the panels across a building in rows, interlocking is facilitated if the panels in alternate rows are reversed. (Figure 4.) The plywood subfloors of adjoining panels slip over the 2" x 4" splines for a tight fit. (Figure 2.) Figure 5 shows additional sections at the walls and at interior supports.

Variation in Size of Panel

The panel can also be made as a 4'-0" x 12'-0" panel. In this case, however, the spline should be built into the panel to stiffen it.

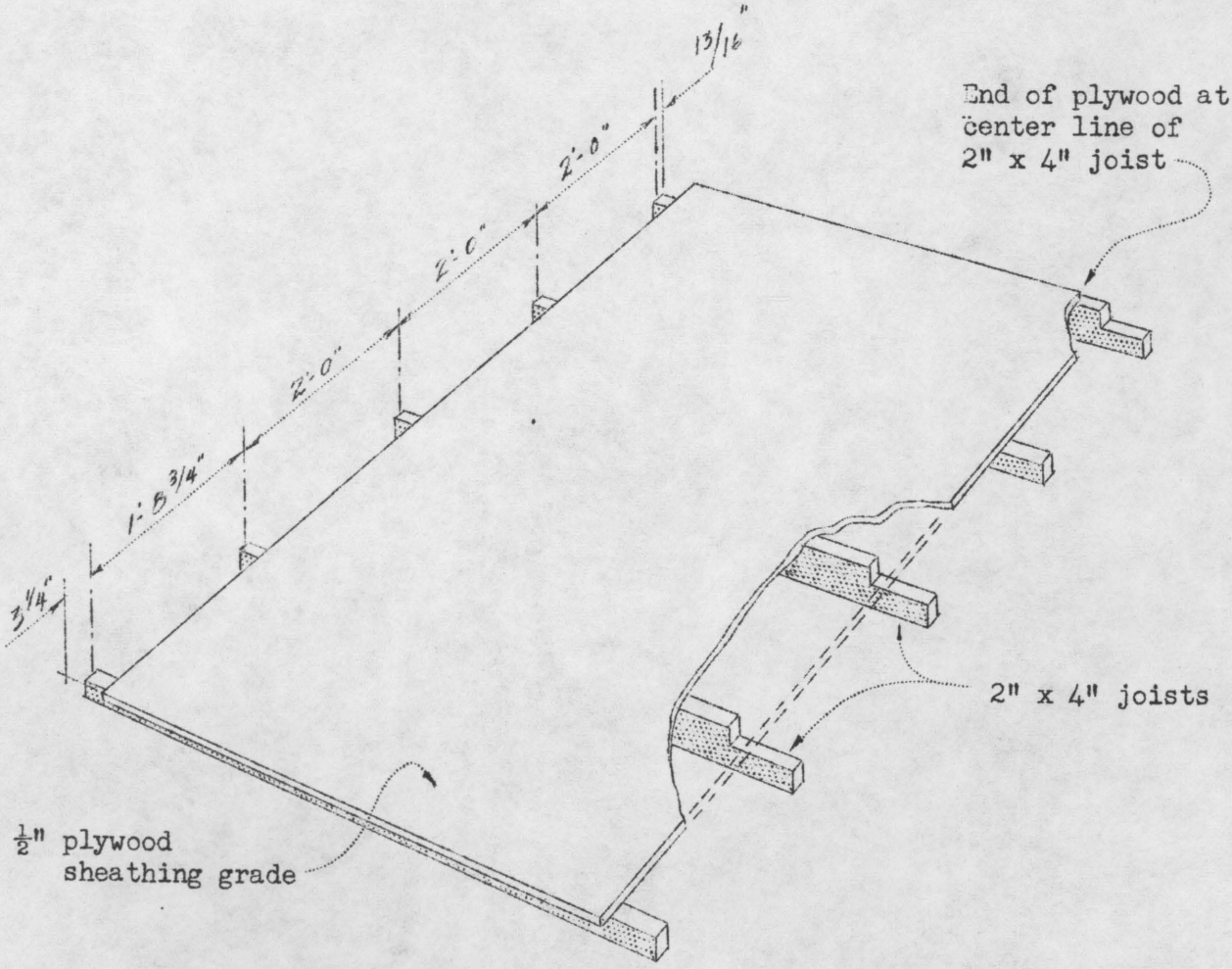


Figure 1 - Panel Using Splines

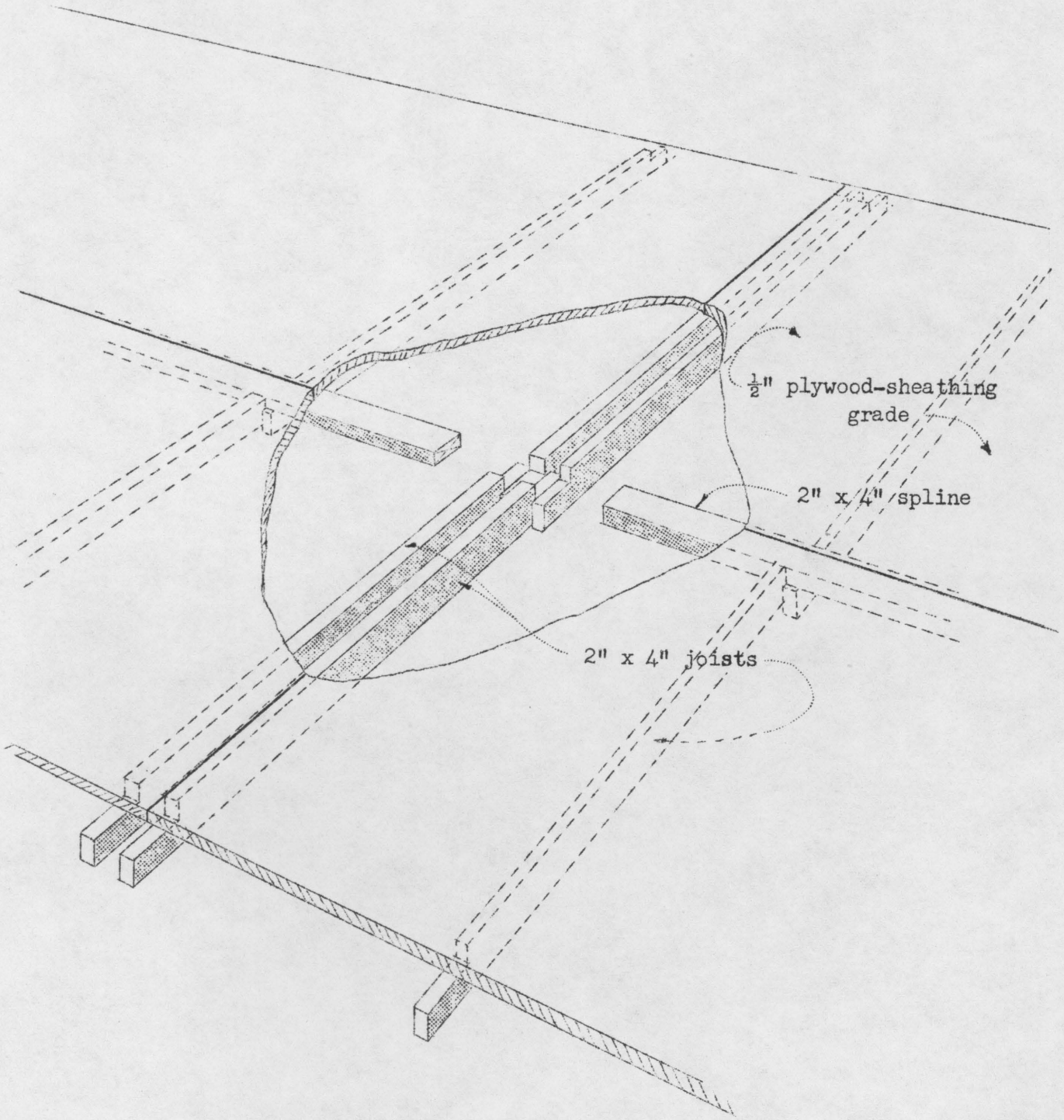


Figure 2 - Splines Serve As Supporting Nailers

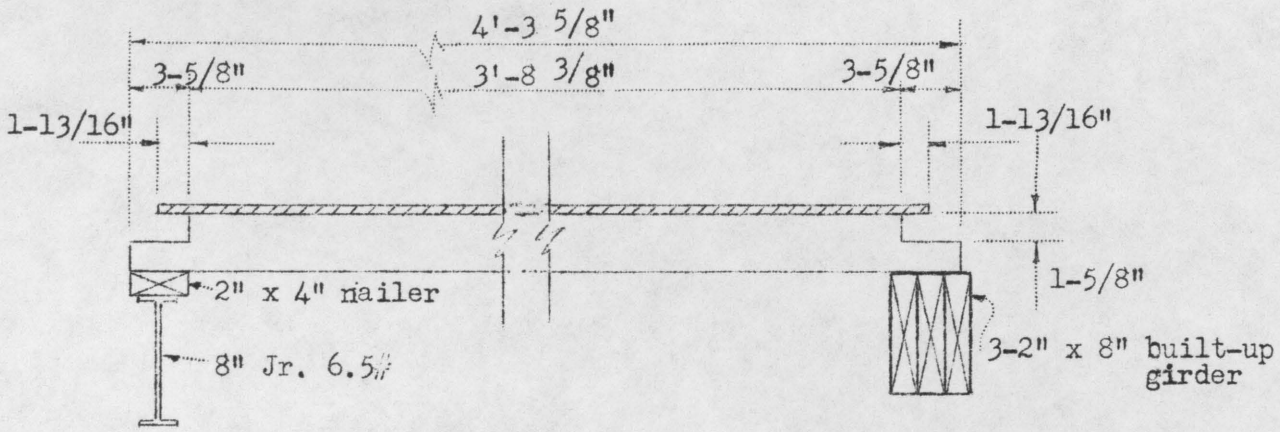


Figure 3 - Cross-Section of Splined Panel on Supports

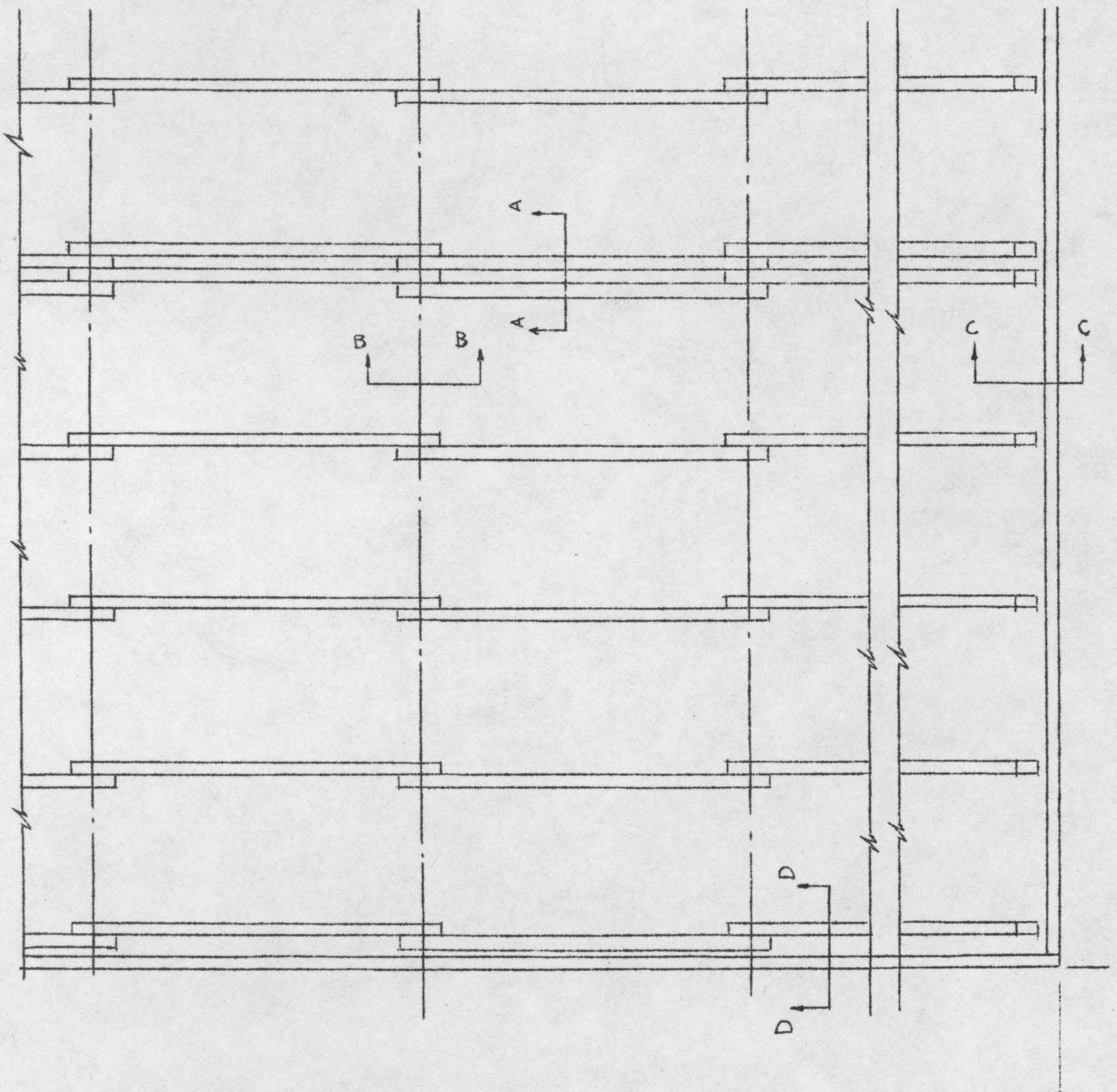
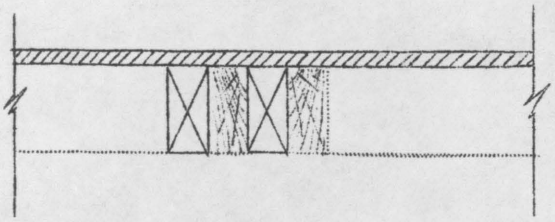
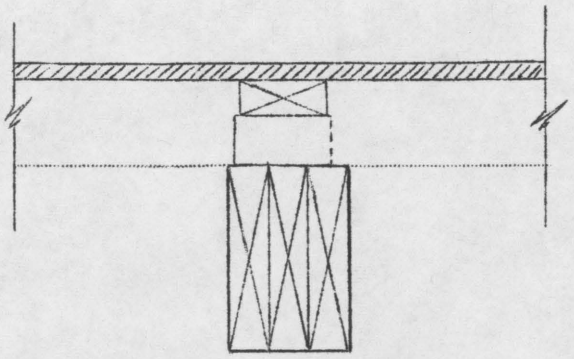


Figure 4 - Framing and Interlocking of Splined Panels



Sec. A-A



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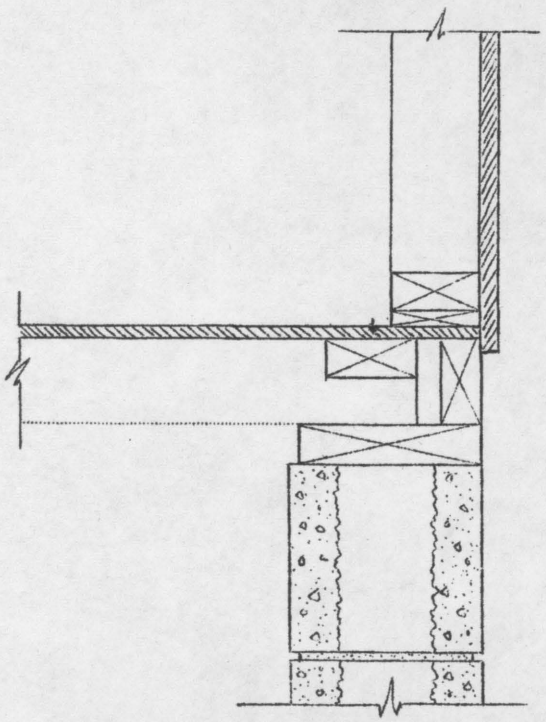

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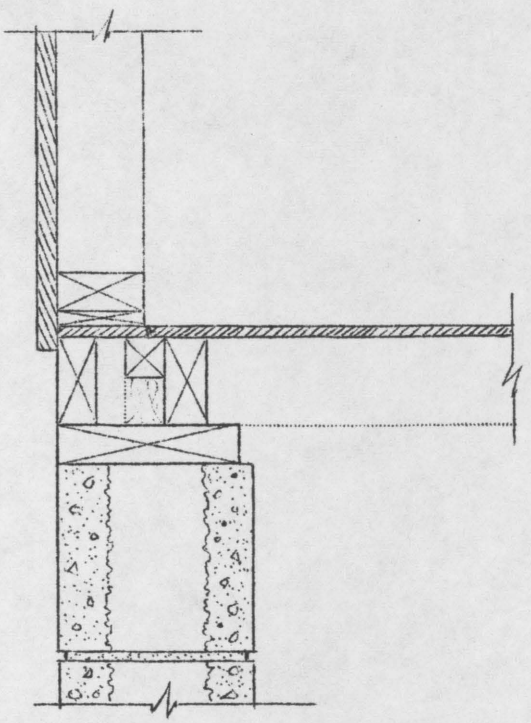

Sec. D-D

Figure 5 - Cross-sections Showing Support of Splined Panels at Walls

Panel Using 2" x 6" Joists (Long Span)

This is a long-span, self-supporting panel. It consists of 2" x 6" joists which support the plywood and the five 2" x 4" cross members. The cross members, which are spaced 2 feet on center, are given additional support by means of 2" x 2" ledgers nailed to the inner faces of the 2" x 6" joists. The joists are 4 feet out-to-out. When two panels are placed side-by-side, double joists 4 feet on center are formed. (Figure 6.) This panel weighs 125 pounds.

By placing the 8-foot panels end-to-end across the building, the floor width can be constructed in multiples of 8 feet. These panels should be supported by girders 8 feet on center running the length of the building.

Similarly, by placing the 8-foot panels end-to-end lengthwise of the building, the floor width can be constructed in multiples of 4 feet. In this case, the girders would run across the building 8 feet on center.

Variation in Size of Panel

If the panel is made 12 feet long instead of 8 feet, 2" x 8" joists placed 4 feet out-to-out should be used instead of 2" x 6" joists. The 2" x 2" ledgers are again used to give additional support to the 2" x 4" cross members. Such a panel weighs 200 pounds.

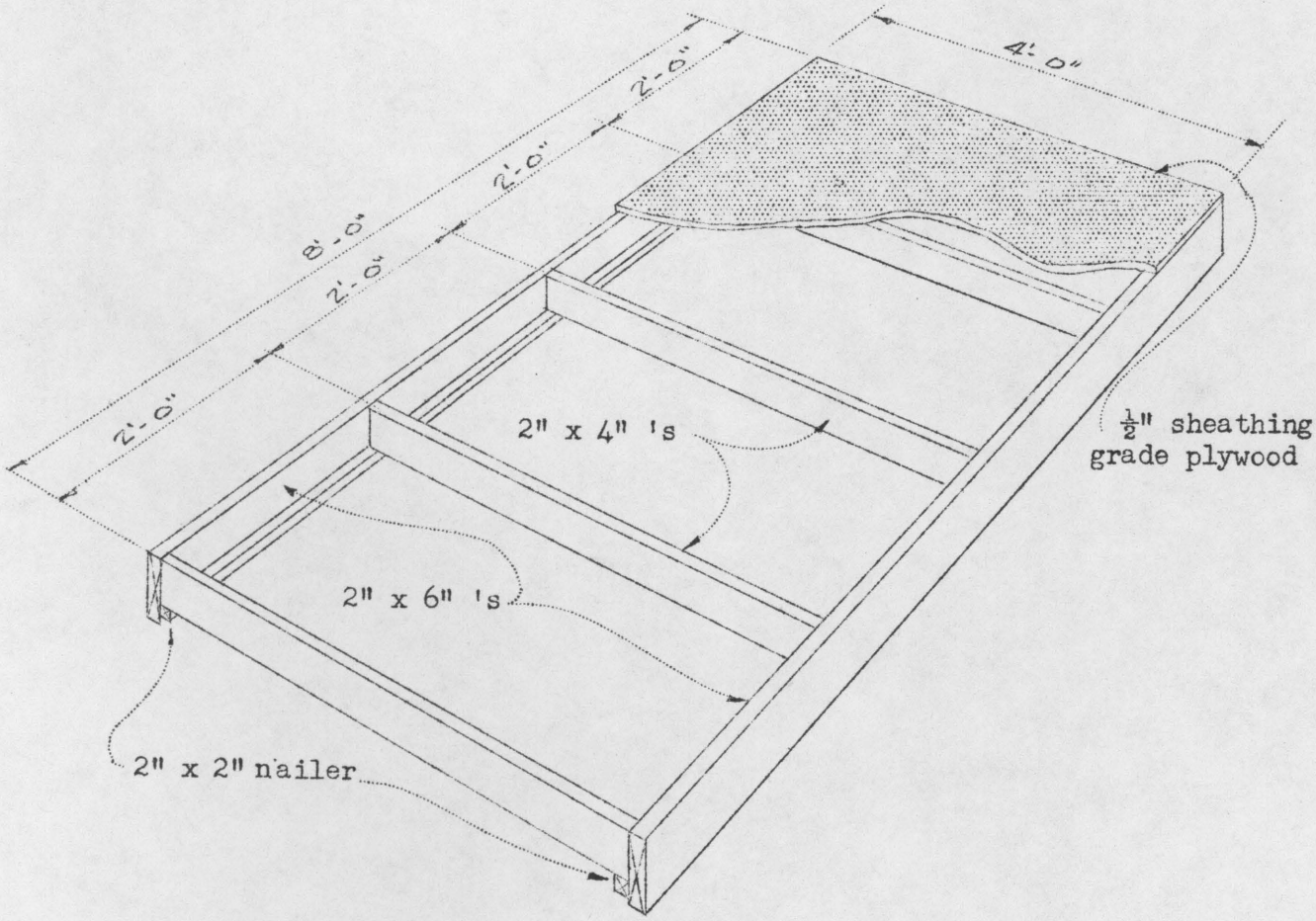

Figure 6 - Panel With 2" x 6" Joists

STRUCTURAL DESIGN DATA

The panels are designed to comply with usual building code requirements for residential floor construction.

For design purposes, a live load of 40 pounds per square foot was assumed. This together with the weight of the panel (4.06 psf) gave a total load of 44.06 psf. Partition loads were considered, based on a 2" x 4" stud partition 8 feet high with plaster on rock lath on both sides. This gave a total partition load of 110 pounds per running foot. These partitions were considered as being placed 1) parallel to, and at the center of, the 8'-0" span; and 2) at right angles to, and at the center of, the 8'-0" span.

Structural design data for the two panels follow:

Panel Using Splines As Connectors

Engineering Analysis of Deflection

Deflection	Plywood	2" x 4" Cross Members
Allowable	0.133"	0.20"
Calculated	0.129"	0.08"

A 2" x 4" of a stress grade of 1100 f will carry a uniform load of 650 pounds over a 4'-0" span with a deflection of 1/360 of the span or .141 of an inch. The loading of 44.06 pounds gives a uniform load per 2" x 4" of 360 pounds with a deflection of .078 of an inch. No concrete-block load test was conducted since the calculated deflection was so much less than the allowable deflection.

Panel Using 2" x 6" Joists

Engineering Analysis of Deflection

Deflection	Plywood	2" x 6" Joists	2" x 4" Cross Members
Allowable	0.133"	0.266"	0.20"
Calculated	0.129"	0.21"	0.073"

Load Test

The maximum deflection of this panel under a concrete-block load test (the blocks averaging 43 pounds each) of 120 psf, was .3125" at the centers of the 2" x 6"'s. Upon removal of the load at the end of the period, there was a residual deflection of .0625" at the centers of the 2" x 6"'s.

COST OF PANELLIZED FLOORS
(Comparison with Conventional Floor Construction)

To compare costs of the two types of panellized floors and conventional construction, flooring for a house 24'-8" x 36'-8" was studied.* It was assumed that 1) the house was over a crawl space, and that the foundation walls, bolts, sill sealers, and termite shields were in place; and 2) the costs of the various floor systems would include the costs of necessary pier footings, piers and girders. All costs are based on labor and material costs in the Champaign-Urbana (Illinois) area.

Piers are used under the two types of floor panels described in this publication and for conventional floor construction. The material for one pier and the estimated cost of the material are given below:

Material for Piers

1 Concrete footing - 24" x 24" x 12"

3 Concrete blocks - 8" x 8" x 16"

1 Solid concrete block- 8" x 3" x 16"

Estimated cost of one pier in place $5.33

* Costs for conventional floor construction are based on labor data obtained from published cost estimating sources. Panel costs are based on man-hour data taken in the laboratory.

Conventional Floor Construction

With Subfloor of Shiplap

Material

3 Piers with footings			$ 15.99
Girders	3 -- 2" x 8"	21.60	
Sills	2" x 8" and 2" x 10"	55.80	
Joists	2" x 10" - 24" o.c.	133.05	
Bridging	1" x 4" - 2 double rows	18.60	
Subfloor	1" x 8" shiplap, diagonal	155.25	
			384.30

Labor

Carpenters -	47 manhours @ $3.00	141.00	
Laborers	13½ manhours @ 2.30	31.05	
"Burden"	47 manhours @ .30	14.10	
	13½ manhours @ .23	3.11	
			189.26
	TOTAL COST		$589.55

With Subfloor of ½" Plywood

Material

3 Piers with footings			15.99
Girders	3 -- 2" x 8"	21.60	
Sills	2" x 8" and 2" x 10"	55.80	
Joists	2" x 10" - 24" o.c.	133.05	
2" x 10" Nailers (instead of bridging)		45.00	
½" Plywood (instead of shiplap)		188.16	
			443.61

Labor

Carpenters -	35 manhours @ $3.00	105.00	
Laborers	2 manhours @ 2.30	4.60	
"Burden"	35 manhours @ .30	10.50	
	2 manhours @ .23	.46	
			120.56
	TOTAL COST		$580.16

Panellized Construction Using Panels With 2" x 6" Joists

27 Panels

Material for one panel

2 2" x 6" side joists 2 2" x 2" ledgers 5 2" x 4" cross joists		$ 4.95	
1 4' x 8' x ½" plywood		6.72	
Labor for one panel			
Carpenters	1/3 manhour @ $3.00	1.00	
"Burden"		.10	
Cost of one panel			$12.77
Cost of 27 panels			$344.79

Setting and Edge Finishing

Material			
1 4' x 8' x ½" plywood		6.72	
Nailers 2" x 2"		6.00	
			12.72
Labor			
Carpenters	13 manhours @ $3.00	39.00	
Laborers	7 manhours @ 2.30	16.10	
"Burden"	13 manhours @ .30	3.90	
	7 manhours @ .23	1.61	
			60.61
6 Piers with footings		31.98	
2 Girders 3 - 2" x 8"		43.20	
Sills 2" x 8" and 2" x 6"		43.35	
			118.53
		TOTAL COST	$536.65

Panellized Construction Using Splined Panels

27 Panels

Material for one panel

5 2" x 4" cross joists	$ 2.00	
1 4' x 8' x ½" plywood	6.72	
Labor for one panel		
Carpenters - 1/3 manhour @ $3.00	1.00	
"Burden"	.10	
Cost of one panel		9.82
Cost of 27 panels		$265.14

Setting and Edge Finishing

Material

1 piece ½" plywood		3.34

Labor

Carpenters -	10 manhours @	$3.00	30.00
Laborers	3 manhours @	2.30	6.90
"Burden"	10 manhours @	.30	3.00
	3 manhours @	.23	.69
			40.59

Sills 2" x 8" and 2" x 4"	37.20	
Splines 2" x 4"	24.00	
		61.20
TOTAL COST OF PANELS IN PLACE		$370.27

The total cost of constructing a floor using splined panels will vary with the girder design.

Girder Options

1.	Panels in Place	$370.27	
	#126W O.W. steel joists, 24'-0" long, in place -- 8 @ $25.00	200.00	
	TOTAL COST		$570.27

or

2.	Panels in Place	$370.27	
	#82W O.W. steel joists, 12'-0" long, in place -- 16 @ $7.50	120.00	
	8 piers @ $5.33	42.64	
	TOTAL COST		532.91

or

3.	Panels in Place	370.27	
	8" x 2¼" x 6.5# Junior Beams, 24'-0" long, in place with 2" x 4" nailers -- 8 @ $18.50	148.00	
	8 piers @ $5.33	42.64	
	TOTAL COST		560.91

or

4.	Panels in Place	370.27	
	Built-up wood girders, 2 -- 2" x 8" on 8'-0" span, 24'-0" total length-- 8 in place @ $11.10	88.80	
	16 piers @ $5.33	85.28	
	TOTAL COST		544.35

or

5. Panels in Place		$370.27
Built-up wood girders, 2 -- 2" x 10" on 12'-0" span, 24'-0" total length-- 8 in place @ $12	96.00	
8 piers @ $5.33	42.64	
TOTAL COST		$508.91

The girders in Option #5 will carry a combined load of 45# psf with a deflection of less than 1/360 of the span, and will carry a load of 90# psf with a deflection of .452".

Summary of Costs for Various Types of Construction

Conventional floor with diagonal shiplap	$589.55
Conventional floor with plywood	580.16
Panels having 2" x 6" side joists	536.65
Panels having splines	
Girder Option #1	570.27
Girder Option #2	532.91
Girder Option #3	560.91
Girder Option #4	544.35
Girder Option #5	508.91